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ABSTRACT

This handbook discusses the renewable energy resources suitable for use in Maryland. It follows a question and answer format with sections about the following alternative renewable energy sources; solar, wind, wood, water, bio-gas/methane, and geothermal. Each section includes a list of recommended readings, appropriate agencies or organizations, and commercial distributors or manufacturers. There is also an annotated bibliography of selected references about energy. A description of the Maryland State Energy Conservation Plan and the Maryland Energy Policy Office is given. (TM)

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Renewable

Energy Alternatives

In Maryland

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FOREWORD

"Energy crisis" - these two words have given rise to theory after theory, debate upon debate, and seemingly endless speculation. However, one concept concerning the world's energy dilemma is gaining wide acceptance. Simply put, we live in a finite world with many finite resources, including the fossil fuels (oil, natural gas, coal). Our consumption of these finite resources continues to increase while the processes that created them have either stopped or are so slow there is no hope of their keeping up with our demands. Logically, then, we can assume that at some time in the future, we will run low, if not out, of some resources.

The question of when we will run out of nonrenewable resources is a topic of hot debate. Will it be in five years . . . ten years . . . or maybe in one hundred years? Although the year, day, and hour cannot be pinpointed, it seems certain we will inevitably have a greater demand for some of these finite resources than there are supplies remaining to meet that demand. Fossil fuel energy sources are nonrenewable, at least in the sense that the supplies cannot be renewed quickly enough to meet our needs.

On the other hand, there are the renewable energy resources such as wood, the wind, and the sun. Wood grows back, the wind will be around as long as the sun shines, and the sun will probably continue to shine for another five billion years or so. Is it not reasonable and logical, if you will, for us to make use of these renewable energy sources. After all, the wind and sun will still be here many years after most of the oil, coal, and natural gas are gone Why wait until the last minute when we could be using these renewable sources now and, at the same time, be conserving our more precious nonrenewable resources?

This handbook discusses the renewable energy resources suitable for Marylanders' use. Because of prescribed and limited length of the handbook, the discussions are brief and rather general. However, the handbook can be used as a guide to many fine, in-depth texts on renewable energy alternatives. We hope you will make use of the references and recommended reading lists.

Energy Policy Office

MARYLAND'S ENERGY
CONSERVATION PROGRAMS

On December 22, 1975, the federal Energy Policy and Conservation Act (Public Law 94-163) was enacted. Success of this program depends on strong state participation and leadership. Consequently, the act has initiated a state energy conservation grant program to provide encouragement and financial aid to the states to establish their own conservation plans.

The Maryland State Energy Conservation Plan has been developed to help to accomplish the goals of the national law. Maryland's ultimate goal, as declared by the Energy Conservation Plan is to decrease the State's projected energy demand for 1980 by seven percent. There are four basic concepts through which the State hopes to meet its objectives. These are (quoted directly here from the "State of Maryland Energy Conservation Plan Executive Summary"):

(1) The State government, through its own conservation efforts will be a model energy conserver as an example for the citizens of the State. The goal for the State government will be a ten percent reduction in demand for energy by 1980.

(2) State conservation efforts will reach all social and economic sectors, including private, commercial, industrial, and utilities. In this way the costs and benefits of conservation will be distributed among all the citizens of the State.

(3) Programs established in the Plan will focus on improving the well being of the citizens of the State by minimizing the economic impact of rising energy costs as well as the cost of implementing conservation options.

(4) The Plan will, as far as possible, complement and enhance federal conservation efforts, programs and policies in order to assure that national energy goals are met.

An agency of the Department of Natural Resources, Energy and Coastal Zone Administration, the MARYLAND ENERGY POLICY OFFICE (EPO) provides the leadership for the coordination and implementation of the programs and activities outlined in the Energy Conservation Plan.

There are six target audiences: (1) Public Sector (State and local government); (2) Residential Sector; (3) Commercial Sector; (4) Industrial Sector; (5) Transportation Sector; and (6) Utility Sector. Specific activities and measures have been prescribed (or are under study) to encourage energy conservation on the part of each of these sectors. The programs for the Residential Sector may be of special interest to you.

Started in July 1977, the Maryland Home Energy Saver's Program (MHES) is a federally funded educational outreach program. Its objective is to help distribute literature about home weatherization and conservation techniques. As a participant

in the program, you would learn to perform an energy audit of your own home and how to figure personal costs and energy savings by taking the steps recommended in the free MHES handbook.

If you would like to find out more about MHES or you have any questions about energy conservation, including renewable alternatives, call EPO on their HOTLINE at 1-800-492-5903 (toll free).

The EPO publishes a newsletter, EPO INFO. It also maintains a reference library, open to the public during normal working hours, in downtown Baltimore. Also, EPO will provide speakers, make film presentations, and set up exhibits for groups of interested citizens. A pilot Energy Savings Clinic, a ten-session workshop series regarding energy management methods, is planned as well.

The examples mentioned here are only a taste of the many plans and activities of EPO. If you are not already familiar with EPO, you may find it worth your while to find out more about their current and proposed projects. The people there make every effort to respond to all mail and telephone requests for information, questions, complaints, and suggestions.

Energy Policy Office
1302 State Office Building
301 West Preston Street
Baltimore, Maryland 21201

301-383-6810

Toll-Free HOTLINE
1-800-492-5903

Source: "State of Maryland Energy Conservation Plan Executive Summary," EPO, September 1977. Donald E. Milsten, Director.

SOLAR

The sun was formed approximately nine billion years ago, and it is expected to remain active another four billion years (an infinite and renewable energy source from our mortal perspective).

For thousands of years, man has indirectly harvested solar energy through food crops and wood. Later in man's cultural development, windmills were built to extract power from the air currents brought about by solar heating of the earth's land and water surfaces.

Within the last three centuries, coal, oil, and natural gas were discovered and used; all of these fossil fuels were indirectly derived from the sun as well. It is interesting and paradoxical, therefore, that the sun is only recently gaining widespread acceptance as a potential energy source.

1. What are the potential uses of solar energy?

   If we exclude food, wood, wind generators, and water wheels, which are all indirectly powered or derived from the sun, and look to the direct utilization of solar radiation, we find many potential uses of "Old Sol":

   a. Space heating of homes, businesses, and industries

   b. Heating of water for homes, and industries

   c. The purification of water by the evaporation and distillation of fresh water from salt water

   d. Drying of food crops to preserve and extend their lifetime "on the shelf"

   e. Cooking of food

   f. Generation of electricity through photovoltaic cells which directly convert solar radiation to the movement of electrons. Electricity can also be produced by generators driven by turbines powered by solar heated, pressurized fluids.

   g. Air conditioning through "heat pumps" powered by solar heated fluids

2. Is solar energy feasible?

   Technologically, solar energy is very feasible to meet low-grade heating needs such as space heating and water heating.

   Economically, solar energy is feasible in some situations but is not practical in others.

3. Is solar energy economically feasible in Maryland?

   A recent federal energy study states that solar water heaters are now cost competitive with other fuel sources in Maryland with the excep-

tion of natural gas. When price ceilings on natural gas are lifted or prices continue to rise at inflationary rates for natural gas in the next few years, solar water heaters should be competitive with gas water heaters as well.

The same study projects that solar heating of homes should be cost competitive with other fuels in the mid-1980's in Maryland.

The economic practicality or feasibility of solar heating largely hinges on whether you are able to build your own solar system. Tremendous savings can be made by building your own system.

A member of the Foundation for Self-Sufficiency (in Maryland) built his own retrofitted solar heating system which is supplying between 15 and 40 percent of the space heating needs of his home (the percentage of the total heating varies with the month in the winter season).

The solar system was hand-built for about $3,500. If purchased from a commercial manufacturer, it would have cost between $10,000 and $20,000. This hand-built system is economically feasible at $3,500 at this time. It may be debatable whether $10,000 to $20,000 could be considered economically feasible right now.

Of course, many individuals cannot build their own solar systems. Here tax "write-offs" will play a determining role as to whether solar energy is to become economically feasible in the near future.

4. Are solar tax write-offs available in Maryland?

As this handbook goes to press (March 1978), there are no laws in Maryland allowing tax write-offs for solar systems. However, laws are presently being introduced on both the State and national levels for solar tax write-offs, and perhaps this state of affairs will pass before too long.

Individuals interested in this issue are urged to contact the Maryland Energy Policy Office for up-to-date information, especially since solar-related legislation may be passed during this year (1978). The State of Maryland does have a law "on the books" that any solar-related improvement to a home will not raise the property taxes on the home.

5. What kinds of solar systems exist for heating homes or water?

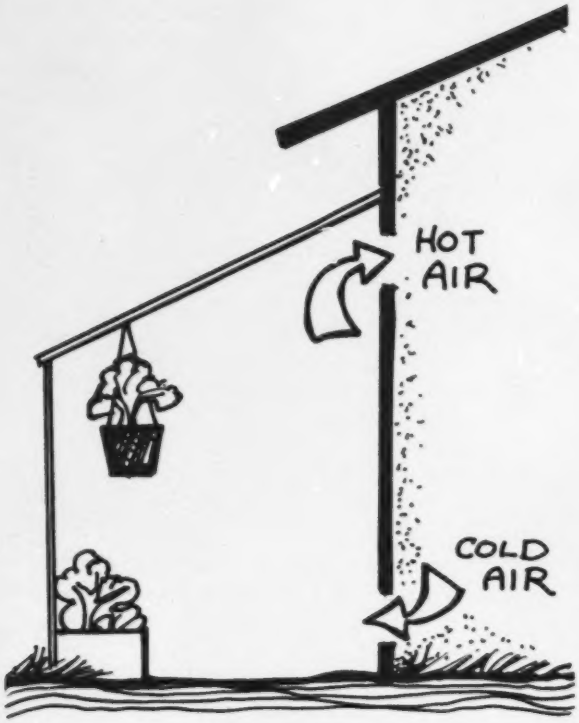
There are two broad categories: (a) passive and (b) active solar systems.

Active solar systems involve hardware such as motors, water pumps, air fans, flat-plate solar collectors, heat exchangers, heat pumps, etc. and usually have an outside energy source such as electricity to drive or operate this hardware.

Passive solar systems are built using as little hardware as possible. An example of a passive solar system is a lean-to greenhouse on the southern face of a house. The hot air generated and rising in the greenhouse (the greenhouse is essentially a large solar collector) is then vented into the house. The cool air in the house vented back into the greenhouse. Extremely informative books about lean-to greenhouses and passive solar heating systems in general are Solar Greenhouse by Rick Fisher and Bill Yanda, The Solar Home Book by Bruce Anderson, and 30 Energy-Efficient Houses You Can Build by Alex Wade and Neal Ewenstein (see references).

In solar systems designed for space heating of homes, the means of transporting heat is either air or water.

Active solar systems using water usually have more efficient solar collectors than air systems. A



water pump often draws less energy (electricity) than an air fan for an active air solar system. However, solar systems using water as a heat transfer medium can encounter freezing problems. Since air cannot freeze (except at temperatures approaching absolute zero), air solar systems have survived severe winters where water solar systems have broken down. Anti-freeze chemicals are used in some water systems. However, this can be an expensive approach to the problem.

Since the sun is not always shining, many solar Homes have heat storage units. Air solar systems usually use bins of rocks as the heat storage medium although in some designs the solar heated air is passed through an "air to water" heat exchanger. The heat is then transferred from the air to water kept in an insulated tank.

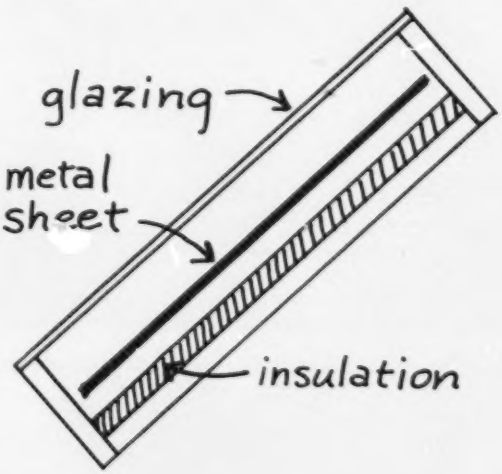
Water solar systems almost always use water as the heat storage medium. Hydrated salts, Glauber's salts, have been experimented with as a heat storage medium, but are not practical at this time because of their tendency to breakdown chemically. The salts become a liquid when they absorb heat and become a gel-like substance when they give up heat. Should the problem of the chemical breakdown of Glauber's salts be solved, the salts could be widely used in the future. The advantage of salts is that they take up far less space than rock bins or water tanks.

6. What kinds of solar collectors are there?

   There are two basic categories:
   (a) flat-plate collectors and
   (b) focusing/concentrating collectors:

   Flat plates often appear as thin rectangular boxes with the side facing the sun covered with glass or transparent fiberglass (one or two sheets). The back of the collector is insulated, and a flat sheet of metal, black in color, is usually housed inside the box. If the flat-plate collector is designed for a water system, then water pipes are often attached to the metal sheet. If it is an air solar collector, then air may just be pumped through the collector box.

   There are many varieties of flat-plate solar collectors other than



the one described. You are referred once again to the Solar Home Book by Bruce Anderson for details.

Focusing/concentrating collectors use reflective surfaces or lenses to concentrate sunlight into a relatively small area where the heat transfer medium is located. The major advantage of focusing collectors is that extremely high temperatures can be reached (2,000 to 4,000 degrees Fahrenheit).

These hot temperatures can then be used to drive engines, heat pumps for air conditioning, and turbines to generate electricity.

However, there are a couple problems associated with concentrating collectors. To operate effectively, they need to be oriented to the sun as it arcs through the sky (this is not the case for flat-plate collectors which can be stationary without too much loss of efficiency). Therefore, complicated sun-tracking mechanisms are needed with focusing collectors.

Secondly, with just the slightest cloud cover diffusing the solar radiation, the focusing/concentrating collector will not function (flat plates can still collect diffuse solar radiation as long as it is not too cloudy).

In cloud-covered Maryland, flat-plate collectors are probably the better choice for solar heating installations.

7. Can I build solar flat-plate collectors myself?

Yes. Many folks who have never held a hammer before have built solar collectors without too much difficulty. Most of the materials for a basic solar collector can be obtained from your local lumber and hardware stores (plywood, shelving boards, corrugated metal).

You can save a lot of money by building you own collector. Solar collectors can be built at home at about $2.50 per square foot of collector surface area. (Commercial solar collectors however cost between $10.00 and $20.00 per square foot.) Therefore, a 1,000-square-foot solar collector built at home will cost somewhere around $2,500 while a commercially manufactured collector the same size can cost between $10,000 and $15,000. The savings you would gain by building your collectors would more than pay for a basic carpentry course and the tools you would need to accomplish the job. Before jumping into a full-scale solar home project however, any solar enthusiast is urged to build a few small-scale solar collectors and conduct tests to his own satisfaction.

Of course the cost of the collectors is just a portion of the cost of the total system. Fans, pumps, and the heat storage unit must be financially accounted for as well. Assuming a ten-percent inflationary rate per year in fuel prices, a solar collector system bought from a manufacturer will pay for itself in about 15 years in terms of the monetary value of the fuel saved.

A home-built solar system (still assuming a ten-percent inflationary rate in fuel prices per year) should be able to pay for itself in 10 years or less.

8. Where can I obtain information about commercially available solar collectors?

The Maryland Energy Policy Office has a list of distributors of solar collectors and solar products in the tri-state area. You can obtain the list by calling or writing to the Energy Policy Office.

The Federal Energy Department also carries literature about solar energy and solar product distribu-

tors. You can reach the Federal Energy Administration at 17 Light Street, Baltimore, Maryland 21202, 962-3983.

Another important source of information is the National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, Maryland 20850, 1-800-523-2929 (toll free).

9. Can solar energy provide 100 percent of the space heating of a house?

Yes, technically it is feasible but it is usually considered uneconomical because of the costs of the increased solar collector area and heat storage. Customarily, 20 to 75 percent (and no more) of total space heating is recommended as the goal for solar heating. It should be noted however that these figures are for a house built above ground.

Underground homes are extremely well insulated by the ground itself and can be totally solar heated with a solar system that would only partly heat an above-ground home.

If you are considering solar energy, you should read as much as you can about the subject. If your home is poorly insulated, your first step is to insulate and winterize it as well as possible. A solar heating system, even if home-built, is an expensive proposition and can be of little worth if the heat collected is immediately lost through doors, windows, and walls.

There are other factors you should consider such as:

a. Do you have an "open" southern exposure on your house to which solar collectors could be adapted?

b. Do you have space for heat storage?

c. Since solar water heaters are used year round, their payback time can be shorter than solar space heating systems. So if you have first insulated your home well and want to move into solar energy, solar water heaters may be the best first choice in solar systems.

RECOMMENDED READING

Direct Use of the Sun's Energy: by Farrington Daniels. Ballantine Books, P.O. Box 505, Westminster, Maryland 21157. $2.20 - This semi-technical book provides sound, basic information on solar energy. It is still considered one of the best solar energy books around.

The Food and Heat Producing Solar Greenhouse: by Rick Fisher and Bill Yanda (1977). John Muir Publications, Box 613, Santa Fe, New Mexico 87501. $6.50 - A very informative book on greenhouses that are heated (for the most part) by the sun. Construction details, tips and suggestions on economical, home-built greenhouses are provided. Emphasis on ways to store heat in the greenhouse, use of the heat generated in the greenhouse for supplemental heating of a home, the best food crops for a greenhouse, and discussion of potential and promising new solar greenhouse designs, are outlined in the book. An excellent summary of solar greenhouses and perhaps the best book presently available on the subject.

30 Energy-Efficient Houses . . . You Can Build: by Alex Wade (1977). Rodale Press, Emmaus, Pennsylvania. $10.95 (hardback) - The solar assisted homes described in this beautifully illustrated book rank as possibly the best designed passive solar shelters being built in this century. The book is well worth every penny, especially for anyone serious about going solar - a highly recommended book for its

information, organization, and artistic form. Obtain it if you can.

Solar Energy Digest: a monthly periodical. S.E.D., Box 17776, San Diego, California 92117. $28.50 per year.

Solar Age: a monthly magazine. Solarvision, 200 East Main Street, Port Jervis, New York 12771. $20.00 per year - A very good periodical with articles for the novice and technician. Interviews, book reviews, and information on solar-related legislation as well as pertinent reports on up-to-date solar projects.

Solar Engineering: a monthly periodical. Solar Engineering, 8435 North Stemmons Freeway, Suite 880, Dallas, Texas 75247. $10.00 per year - Technical but interesting. Reviews of solar homes, products, and manufacturers listed often.

The Solar Home Book: by Bruce Anderson with Michael Riordan (1976). Cheshire Books, Church Hill, Harrisville, New Hampshire 03450. $7.50 - Perhaps one of the best books on solar energy for the layman. Simple, easy to read, and informative. Passive and active solar systems are described with a special focus on individuals who have already built and tested solar heated homes, solar water heaters, etc. Although this is not a "nuts and bolts" (construction) text, it will certainly provide you with a basic understanding of the application and theory of solar heating. This book should be one of the first books a solar novice obtains for his reference and background reading.

The National Solar Heating and Cooling Information Center
P.O. Box 1607
Rockville, Maryland 20850
1-800-523-2020 (toll free)

By calling the toll-free telephone number, you can request basic information on solar energy written in layman's terms, lists of names and addresses of architects and builders specializing in solar energy in your area, lists of books on solar energy, and the latest information on government services and resources near you.

Maryland Energy Policy Office
301 West Preston Street
Baltimore, Maryland 21201
(301) 383-6810
(see section at beginning of this handbook)

The Maryland Energy Policy Office has a reference library which can be used by Maryland residents and lists of local solar product distributors. The office also has information on energy conservation, energy audits, and provides speakers on these subjects.

Foundation for Self-Sufficiency Inc.
Central Maryland Research Center
35 Maple Avenue
Catonsville, Maryland 21228
(Western Maryland Research Center at Three-Springs Fisheries, Lilypons, Maryland; Eastern Maryland Research Center in Easton, Maryland)

A non-profit, tax-exempt organization devoted to backyard research by its members in solar/wind energy, greenhouse/aquaculture systems, and hydroponics. Paid memberships ($12.50 per year) entitle the organization's associates to publications about the various research projects. Members volunteer their spare time to these research projects, a number of them involving solar energy.

School of Living
Heathcote Center
Freeland, Maryland

The Heathcote Center usually holds an alternative energy conference at the end of March each year. Construction of solar collectors and solar information are often on agenda.

wind

Windmills have been used to pump water, grind grain, and perform other simple mechanical tasks since the 12th century. Even today, especially in the West, you can see the American multi-blade windmill (as pictured on the front cover) silhouetted against the sky.

Within the last century, windmills have been adapted to generate electricity. These electricity-generating windmills, more properly called wind generators, have received considerable attention because of the ubiquitous nature of electrical power uses and the possibility of future energy shortages.

1. What are the major differences between windmills used to pump water and wind generators?

   a. The windmills designed for pumping water and other basic mechanical tasks spin at relatively low speeds and generate high torque (a great deal of power but at low speeds).

      The American multi-blade windmill, composed of a number of flat blades, and the Savonius windmill (S-rotor), composed of cylindrically shaped "cups" mounted on a vertical shaft, are examples of these low-speed, but high-torque windmills.

      Precision construction (such as perfect blade balance) is not too essential, because these windmills spin at such low speeds. And, since these windmills present a relatively large surface area to the wind, they can begin operating in low-energy winds (6 to 8 miles per hour).

   b. Wind generators are a different matter. The electrical generator, which is a component of the wind generator, must be rotated at very high speeds if electricity is to be efficiently generated.

      In most cases, the blades of a wind generator are designed to spin at high velocities. The blades are long and slender, resembling those of an airplane propeller. Since the blades spin at high speeds, centrifugal

force can become extreme. The blades must be perfectly balanced or the centrifugal force can tear the wind generator apart.

The wind generator blades are very often of a complicated, curved airfoil design. There are usually only two or three blades, presenting less surface area to the wind. Thus, a wind generator often needs higher energy winds (8 to 12 miles per hour) to begin operating.

The high operating speeds of the wind generator mean the bearings and gearing are subject to tremendous wear. These components must be built with precision if the generator is to have an extended life.

2. What are the best wind speeds for wind generators?

The recommended average wind velocity is 10 miles per hour at the location of any wind generator. However, the average wind speed can be lower if you plan to use a low-speed, high-torque windmill, such as those designed for pumping water.

An average wind velocity of 10 miles per hour or greater can be found along many coastal and mountainous regions of Maryland, but average wind speeds lower than 10 miles per hour are often the case in valleys or tree-sheltered areas in the State.

3. How do you know what the wind speed is in an area?

Wind speed data should be collected in the desired location for the wind generator before you actually decide to use one. This is usually done by using a wind speed recording instrument such as an anemometer.

The average wind speed data should be collected for at least three months or, better yet, over a year. If the data are collected over a short period, they can be compared with the average wind speed data of the nearest airport to note if average wind speed for the proposed wind generator location is generally lower or higher than that of the airport.

Anemometers can be purchased or rented. A listing of companies carrying anemometers can be found in Wind Power Digest: Wind Access Catalog Fall 1977 (see references).

4. Can I purchase a wind generator?

Yes. There are over 17 companies now offering wind generators for sale with a selection of over 25 models. The models range from "Wincharger" by Winco rated at 200 watts at 23 miles per hour to the "Windstream 25" by Grumman Energy Systems rated at 15,000 watts at 26 miles per hour.

See the list of distributors in this handbook as well as Wind Power Digest: Wind Access Catalog Fall 1977 for more information.

5. Can I build a wind generator?

Yes, but it is not easy (see the discussion under 1.b.). You need technical and mechanical competence to build a wind generator "from scratch."

This is not necessarily the case, however, if you are interested in building a water pumping windmill. Water pumping windmills are usually simpler in design and quite a bit easier to construct.

Simplified Wind Power Systems For Experimenters, Wind and Windspinners, and The Homebuilt Wind-Generated Electricity Handbook (see references) are all necessary reading if you are considering building a wind generator.

Some plans are available: Helion sells plans for 12/16 footer wind generator at $10.00 (Helion, Box 4301, Sylmar, California 91342);

M.I. Plans Service sells plans for a budget windcharger (Plans Book PB-2-77, M.I. Plans Service, Fawcett Building, Greenwich, Connecticut 06830) for $15.00.

6. Can I fix up an old wind generator or purchase a rebuilt one?

   Your best option, if you do not have the technical skill/knowledge, is to purchase a rebuilt wind generator.

   Boston Wind Power Company (574 Boston Avenue, Medford, Massachusetts 02155) sells reconditioned and rebuilt Jacobs wind generators. Jacobs wind electric generators were built between the 1920's and 1950's and are still considered by many wind enthusiasts to be the best wind generators ever constructed.

   Many Jacobs models have survived weather and time and are being reconditioned by individuals and small wind apparatus companies, such as Boston Wind Power.

   Mike Hackleman's The Homebuilt Wind-Generated Electricity Handbook discusses the search for old wind generators such as the Jacobs, their removal from the original towers, how they are reconditioned, and once again made operable. This is a good guide if you are up to the work involved in such a project.

7. What do you do when the wind stops?

   a. Stop using electrically driven appliances during that time. There are several American families who have actually taken this approach. Although they have had to alter their lifestyles, they state they do not find it a hardship. In fact, these families feel they have become much more "in tune" with nature.

   b. The more common approach is to store the electricity generated during windy days in an electrical storage system and then to draw upon the stored energy when the wind stops blowing. There have been a number of systems proposed to store the energy (flywheels, hydrogen production and storage, etc.), but the most feasible approach at present is to store the electrical energy in batteries.

      Automobile batteries have been used but are not necessarily the best choice. If all the electricity stored in a car (lead-acid) battery is drawn out at one time, the life of the battery is shortened considerably.

      Deep-cycle batteries (those that can have the electrical energy drawn out of them without destroying their lives) are considered to be better batteries for wind generator systems. Golf cart batteries are examples of deep-cycle batteries.

Nominal Output Rating of Generator (watts)	Average Monthly Wind Speed (mph)					
	6	8	10	12	14	16
	Average Monthly Output (Kw-hrs)					
50	1.5	3	5	7	9	10
100	3	5	8	11	13	15
250	6	12	18	24	29	32
500	12	24	35	46	55	62
1,000	22	45	65	86	104	120
2,000	40	80	120	160	200	235
4,000	75	150	230	310	390	460
6,000	115	230	350	470	590	710
8,000	150	300	450	600	750	900
10,000	185	370	550	730	910	1,090
12,000	215	430	650	870	1,090	1,310

Reprinted from Electric Power from the Wind, Henry Clews.

Various battery manufacturers can be found listed in the Wind Power Digest: Wind Access Catalog Fall 1977. A well-written description of how electrical storage systems work can be found in Electric Power from the Wind by Henry Clews (see references).

c. A third option is to install a synchronous inverter. This is a device that converts the direct current of the wind generator to the alternating 60-cycle current of the utility line. Whenever the wind generator is operating, the electricity is fed back to the utility line, running the electrical meter backwards. When the wind is not blowing, you can draw electricity from the utility company. In a sense, the utility company serves as the storage system. Of course, should there be power brown-outs or black-outs, you would be faced with the same predicament as other utility customers. A synchronous inverter, "Gemini," is available from Windworks.

8. How much electricity can I get from a wind generator?

Any commercially purchased wind generator has a rated output (in wattage). This is the maximum electrical power that can be produced by the wind generator. Most wind generators are designed to reach their rated output in wind speeds between 20 and 26 miles per hour. Since high energy winds in the 20 to 26 miles per hour range occur infrequently, the wind generator is not continually performing at its optimally rated output.

As you would expect, the more wind, the more power from the wind generator. But, the relationship is not a simple one. The actual power available from the wind is proportional to the cube of the wind speed. For example, from a 1,000-watt wind generator (maximum rated output), in a 5-miles-per-hour wind, you might expect 10 watts of power. In a 10-miles-per-hour wind, you could expect about 75 watts, at 15 miles per hour/260 watts, and at 20 miles per hour/610 watts.

In Electric Power from the Wind, Henry Clews developed a chart of the monthly kilowatt-hour output for wind generators (at various ratings) and at differing monthly average wind speeds. The chart has been reprinted in this handbook.

The American electricity consumer is very apt to use well over 200 kilowatt-hours of electricity per month (1 kilowatt equals 1,000 watts). Depending on the number of electrical appliances in the home the electrical consumption can easily reach 1,000 kilowatt-hours per month. If you know you are consuming a specific number of kilowatt-hours of electricity per month, you can refer to Henry Clew's chart to see the size wind generator you would need given a certain monthly average wind speed.

Of course, if you are serious about purchasing a wind generator, you would be wise to keep a record of the actual kilowatt-hours personally consumed per month. This can be done by reading your electric power meter (and comparing your readings with the power company's) and keeping a month-by-month record.

9. How much do wind generators cost?

It can cost between 1 and 2 dollars per watt generation capacity of the wind generator. For example, a 200-watt wind generator can cost between 200 and 400 dollars, while a 2,000-watt generator can cost between 2,000 and 4,000 dollars.

These costs do not include batteries and other accessories, such as the wind generator tower. Thus, a wind generator is equivalent in cost to an expensive car (a car, of course, consumes energy, while a wind generator produces it).

Although the costs of wind generators seem high, they are still cost effective, particularly in some rural areas. In the future, with rising fuel price, wind generators may very well become cost competitive with existing electrical energy sources.

10. Are large-scale wind generation systems being investigated?

Yes. The federal Energy Department is funding the research of large-scale wind systems and a number of large prototype wind generators are presently being built and tested. Dr. William Hemonemus of the University of Massachusetts has proposed large-scale wind generator systems that could be built on floats and set off the ocean coasts. These large-scale systems might be applicable to provide power to Maryland's coastal areas. The electricity generated could be fed into the State and national power grids.

The following Recommended Reading list has been compiled for readers interested in continuing their own reading into wind generator systems in-depth.

RECOMMENDED READING

Simplified Wind Power Systems for Experimenters: by Jack Park (1974). Helion, Box 4301, Sylmar, California 91342. $6.00 - An excellent book describing the power output and advantages and disadvantages of various windmill/wind generator designs. How the airfoil blades work is described as well as a method of graphing different airfoils is presented. This is a recommended book for individuals who want to obtain a semi-technical guide to wind generator design. The steps Jack Park outlines are: (1) determine the power needed; (2) determine the wind energy available; (3) determine the configuration and size of windmill required to obtain power required from energy available; and (4) design the components of the windmill to satisfy aerodynamics and structural requirements.

Electric Power from the Wind: by Henry Clews (revised edition 1975). Solar Wind Publications, P.O. Box 7, East Holden, Maine 04429. $2.00 - A booklet in non-technical language describing the "whys," "whats," and most particularly the "hows" of

wind generator systems. General introductory reading, but very informative nevertheless.

Wind Power Digest: published by J. Evans. A quarterly periodical. Wind Power Digest, 54468 CR 31, Bristol, Indiana 46507. Subscription, $6.00 per year (4 issues) - This is perhaps the best periodical on windmills/wind generators presently available. Articles are technical and non-technical in nature ranging from interviews with wind researchers to specific plans for building wind generators. Reviews of books, products, and wind power legislation are of common occurrence in each issue. A very informative Wind Power Digest is the Wind Access Catalog Fall 1977 (mentioned in text), available for $2.00. This issue lists distributors of batteries, wind towers, wind generators, and anemometers.

The Homebuilt, Wind Generated Electricity Handbook: by Michael Hackleman (1975). Earthmind, 5246 Boyer Road, Mariposa, California 95338. $10.00 - A truly valuable "nuts and bolts," step-by-step book on the reconditioning of previously discarded wind generators. The table of contents includes: (1) Expeditions; (2) Wind Machine Restoration; (3) Towers; (4) Installing the Wind Machine; (5) The Control Box; (6) Auxiliary Electricity - Generating Equipment; and (7) Wind Machine Design Notes. This book is a logical follow-up to Hackleman's previous book, Wind and Windspinners.

Wind and Windspinners: by Michael Hackleman. Earthmind, 5246 Boyer Road, Mariposa, California 95338. $7.50 - An extremely informative book about the construction of a Savonius rotor. However, it also covers subjects such as alternators, care and charging of batteries, testing of used batteries, regulators, wiring, etc. Complete and clear.

Wind Power Climatology of the United States: by Jack W. Reed. U.S. Energy Research and Development Administration, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830. $7.60 - Wind data from 758 stations. Data analyzed for average wind speeds during the month, season, and year.

ORGANIZATIONS

American Wind Energy Association
54468 CR 31
Bristol, Indiana 46507

An organization which supports wind power on a legislative level and community level (through workshops). Members receive the AWEA Newsletter, the Wind Power Digest, and reduced rates on other AWEA publications and activities. Dues: $25.00 per year.

Windworks
Route 3, Box 329
Mukwonago, Wisconsin 53149

An engineering and consulting firm on wind energy systems. They developed the Gemini Synchronous Inverter and carry descriptive literature on wind generators. Their research and prototype wind systems are primarily small scale.

WIND SYSTEM DISTRIBUTORS

Alternate Energy Systems
150 Sandwich Street
Plymouth, MA 02360
(617)747-0771

Automatic Power
P.O. Box 18738
Houston, TX 77023
(713)228-5208

Dean Bennett Supply Co.
4725 Lipan Street
Denver, CO 80211
(303)433-8291

Coulson Wind Electric
RFD 1, Box 225
Polk City, IA 50226
(515)984-6038

Edmond Scientific Co.
380 EDS Corporation Bldg.
Barrington, NJ 08007
(609)547-3488

Empire Energy Development Corp.
3371 West Hampden Avenue
Englewood, CO 80110
(303)

Environmental Energies, Inc.
P.O. Box 73
Copemish, MI 49625
(616)378-2000

Energy Alternatives
69 Amherst Road
Leverett, MA 01054
(413)549-3644

Energy Development Co.
179 East Road No. 2
Hamburg, PA 19526
(215)562-8856

Energy 2000
c/o Robert Herbert
Winstead, CT

Enertech Corp.
P.O. Box 420
Norwich, VT 05055
(802)649-1145

Environmental Resource Group
Taft Corners
Williston, VT

Garden Way Laboratories
Charlotte, VT 05445
(802)425-2147

Independent Power Developers
P.O. Box 1467
Noxon, MT 59853
(406)847-2315

Independent Energy Systems
6043 Sterrettania Road
Fairview, PA 16415
(814)868-6211

Independent Energy Co.
75 Minuteman Drive
Concord, MA 01742

Kramco
P.O. Box 1536
Allentown, PA 18105

Prairie Sun & Wind Co.
4408 62nd Street
Lubbock, TX 79409

Real Gas & Electric
P.O. Box 193
Shingletown, CA 96088
(916)474-3556

Sunflower Power
Route 1, Box 93-A
Oskaloosa, KS 66066
(913)597-5603

Sigma Engineering
P.O. Box 5285
Lubbock, TX 79417
(806)762-5690

Windependence Electric
P.O. Box M1188
Ann Arbor, MI 48106
(313)769-8469

Windlite-Alaska
P.O. Box 43
Anchorage, AK 99510
(907)272-2205

WOOD

Our forests can be counted as sources of renewable fuel only if their timber is used carefully, and sound reforestation practices are followed closely. Our woodlands have already suffered somewhat from early mismanagement. When Father Andrew White, chaplain to the first Maryland colonists, landed at St. Mary's City, he was awed by the "fine groves of trees . . . not choked with thorns or undergrowth, but growing at intervals as if planted by the hand of man, so that you can drive a four-horse carriage wherever you choose through the midst of the trees" (Vokes 1957, p. 163).

In Father White's time, there were millions of tall, robust trees. Today, the 400-year-old Wye Oak in Talbot County is just about the only one of its kind remaining of those original forests. Marylanders have not always shown much foresight as they cut down the best kinds of trees, leaving the less desirable types. Replanting was unheard of; the less useful trees gradually took over the land where the finest ones had grown before.

Fortunately, this lack of management of our State's forest land is no longer allowed. According to the U.S. Forest Service, there are approximately 2,885,000 acres classified as commercial forest land in Maryland today (Ferguson 1967). This acreage represents about 46 percent of the State's land area. Most of this forest land is privately owned, much in small forests of 30 acres or so (Ferguson 1967).

The term commercial is used to designate land that is or can be used to produce timber, land that is economically accessible, and is not protected through statute, ordinance, or administrative order. The 18,000 acres of forest land set aside as State parks or owned by federal organizations, principally the National Park Service, are classified as noncommercial.

Regionally, Maryland's forests are most dominant in mountainous Western Maryland, in Southern Maryland (western shore), and the easternmost half of the Eastern Shore. The rest of the State is also well endowed with forest land. Even the counties with the densest populations have nearly 40 percent of their land area in commercial forest land. The projections for Maryland's timber production over the next 20 years are encouraging (Ferguson 1967). Much of the forest land has not been developed to anywhere near its fullest potential.

Looking to wood as an alternative fuel in Maryland is a promising and reasonable measure for us to take to conserve our more precious supplies of nonrenewable fossil fuels. But, we must go about it in a sensible, informed, and level-headed way, always keeping tabs on our future needs as

well as our pressing needs of the present.

Here are a few preliminary questions and answers you may find helpful.

1. How can I find firewood to buy?

   a. Keep an eye on the classified ads in the newspapers.

   b. Check the "Yellow Pages" of your telephone book.

   c. Ask a friend or neighbor who uses firewood.

2. When is the best time to order firewood?

   It is best to order your wood during the late summer/early fall. The season has no bearing on the cost or quality of the wood. Ordering early gives the supplier time to cut enough wood for his customers. Being an "early bird" will give you a better chance of having enough wood to last through the winter.

3. Where can I find free firewood?

   a. Sawmills often give away slabs and mill ends.

   b. Lumber yards occasionally have scraps for the taking.

   c. Contractors sometimes give away scrap wood at construction or demolition sites. Be on the lookout for land development projects; builders often have to clear the land before they can begin construction. One note of warning about taking wood from demolition sites is THE RUBBLE CAN BE VERY DANGEROUS. Be sure to ask for permission first.

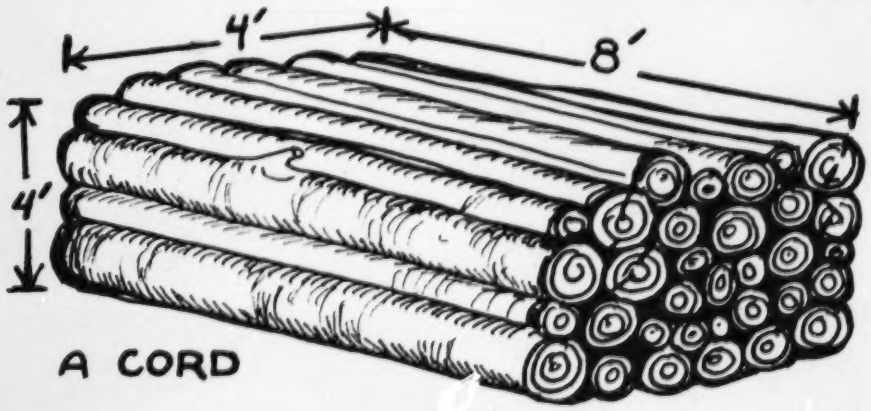
   d. Sometimes you are permitted to remove dead wood from State parks or national forests. Contact your local office of the U.S. Forest Service (if applicable), your regional State Forester, your county's Agricultural Stabilization and Conservation Committee, or a park ranger. Some parks require you to obtain a permit for this purpose (free-of-charge).

   e. Contact the Maryland Energy Policy Office for tips.

4. What types of wood are available in Maryland?

   There are about 120 different species of trees growing in our State (Vokes 1957, Brown and Brown 1972). Most of the woods listed in the table are available somewhere in the State. Again, you should check with your regional State Forester to find out which woods are available in your area and which are best for heating.

   Harold E. Vokes' book, Geography and Geology of Maryland, lists each species and shows in which counties each can be found (pp. 164-167).



Table

RATINGS FOR FIREWOOD

Names of trees	Relative amount of heat	Easy to burn	Easy to split	Does it have heavy smoke?	Does it pop or throw sparks?	General rating & remarks
Hardwoods:						
Ash, red oak, white oak, beech, birch, hickory, hard maple, pecan, dogwood	high	yes	yes	no	no	excellent
Soft maple, cherry, walnut	medium	yes	yes	no	no	good
Elm, sycamore, gum	medium	medium	no	medium	no	fair - contains too much water when green
Aspen, basswood, cottonwood	low	yes	yes	medium	no	fair - but good for kindling
Chestnut, yellow-poplar	low	yes	yes	medium	yes	poor
Softwoods:						
Southern yellow pine, Douglas-fir	high	yes	yes	yes	no	good - but smoky
Cypress, redwood	medium	medium	yes	medium	no	fair
White-cedar, western red cedar, eastern red cedar	medium	yes	yes	medium	yes	good - excellent kindling
Eastern white pine, western white pine, sugar pine, ponderosa pine, true firs	low	medium	yes	medium	no	fair - good kindling
Tamarack, larch	medium	yes	yes	medium	yes	fair
Spruce	low	yes	yes	medium	yes	poor

Source: U.S. Forest Products Laboratory. (In: Dahlin 1974).

5. Generally, what are the differences between hardwoods and softwoods as firewood?

   a. Hardwoods produce more heat over a longer period of time. Two pounds of dry hardwood have about the same value as a pound of good quality coal.

   b. Softwoods are easier to ignite and give a quicker, hotter fire than hardwoods. They are also easier to split. However, they tend to produce more smoke than hardwoods.

6. What are the units used to measure firewood?

   A cord is a stack of wood measuring 4 x 4 x 8 feet (128 cubic feet). This unit yields about 80 cubic feet of solid wood; the remaining 48 cubic feet are air space.

   Wood is also sold by the face cord (4 x 8 feet cut into any desired length). A rick is a 4-x-8-foot stack of 16-inch logs.

   Costs for each unit vary according to wood type, age, and distance hauled. In Baltimore County area newspapers, for example, cords of wood are advertised for sale at prices ranging from 50 dollars to 65 dollars.

7. How can I use wood as a fuel in my home?

   Basically, there are two types of wood-burners: (a) open heaters such as fireplaces; and (b) enclosed heaters ("complete combustion") such as Ashley heaters and closed metal stoves.

8. Which type of burner is more efficient?

   The enclosed heaters are more efficient than fireplaces. A fireplace is probably the most wasteful wood-burner there is. Most fireplaces have no means of controlling the amount of air that enters them, and the rapid movement of air (convection) up the chimney can actually empty the room of warm air with a siphoning effect.

   However, recent improvements include glass fire-doors that restrict drafts but radiate heat into the room; grates made of hollow pipes that take in cold air and blow out warm air by natural convection (some have fans); ventilating and fan systems that recirculate and distribute the air more efficiently into the living area.

9. Where can I buy a wood-burning unit?

   Again, look in the "Yellow Pages," call the Maryland Energy Policy Office. A list of some major manufacturers is included here. Write to them for their catalogs and lists of local distributors. Prices for units vary according to availability and quality and can range from 100 dollars to over 500 dollars. If you decide to purchase a wood-burner, DO NOT WAIT UNTIL WINTER TO ORDER!

10. What about buying a secondhand stove?

    Beware of large cracks, rusted-out parts, warps, and missing parts. If at all possible (or applicable), ask to see the stove in operation.

11. Will my homeowner's insurance increase if I install a wood-burner?

    Probably. This is because many people have been installing wood-burners without taking the proper safety precautions, and because they do not know how to use their equipment correctly. Therefore, in the insurance companies' eyes, risk of damage to houses with wood-burners has proven to be greater than in homes without.

    It is very important for you to consult with your fire department, a building inspector, and/or the

National Fire Protection Association. Having a wood-burner carries greater responsibility than a conventional furnace - YOU CANNOT SIMPLY TURN OFF YOUR ROARING FIRE WITH THE FLIP OF A SWITCH OR THE TWIST OF A THERMOSTAT!

12. I own land and would like to look into starting my own woodlot program. Where do I begin to look for help getting started?

    If you are in a position to start your own woodlot program, you may qualify for cost-sharing aid under the Forestry Incentives Program. This program was created by Congress in 1973 to help small landowners (holding less than or equal to 500 acres) produce timber for environmental improvement or to increase growth of selected trees for cutting. Contact your State Forester and/or local Agricultural Stabilization and Conservation Committee for details.

    Even if you do not qualify for the cost-sharing aid program, your State Forester can offer valuable information and assistance.

These questions and answers are but a sample of the information available to you in the references listed as "Recommended Reading." The books included on this list present vital aspects of using wood as heating fuel such as how to calculate the amount of fuel you need, how to select the type of wood-burner best suited to your needs and pocketbook, many inside tips offered by people who have been using wood-burners for some time, and so on.

References Cited

Brown, Russell G. and Melvin L. Brown. 1972. Woody Plants of Maryland. College Park, Md.: University of Md.

Dahlin, Dennis. 1974. "Home Heating With Wood." In: Energy Primer, pp. 154-166. Menlo Park: Portola Institute.

Ferguson, Roland H. 1967. The Timber Resources of Maryland. (U.S. Forest Service Resource Bulletin NE-7). Upper Darby, Pa.: Forest Service, U.S. Department of Agriculture.

Vokes, Harold E. 1957. Geography and Geology of Maryland. Baltimore: Maryland Geological Survey.

RECOMMENDED READING

The Complete Book of Heating With Wood: by Larry Gay (1974). Garden Way Publishers, Charlotte, Vermont 05445. $3.00.

Woodburners' Handbook: by David Havens (1973). Media House, Box 1770, Portland, Maine 04104. $2.50.

Maine Times' Field Guide to the Wood Stoves: by Maine Times, 41 Main Street, Topsham, Maine 04086. $0.50.

RAIN Magazine's Consumers' Guide to Wood Stoves: (Journal of Appropriate Technology) by RAIN, 2270 Northwest Irving, Portland, Oregon 97210. $0.75.

Wood Burner's Encyclopedia: by Jay Shelton and Andrew Shapiro (1976). Vermont Crossroads Press, Box 333, Waitsfield, Vermont 05673. $6.95.

Wood 'n Energy: by the Society for the Protection of New Hampshire Forests, 5 State Street, Concord, New Hampshire 03301. Subscription is $5.00 per year.

Firewood for Your Fireplace: by U.S. Department of Agriculture (U.S. Forest Service). Superintendent of Documents, Washington, D.C. 20402. Document no. 0100-03195. $0.25.

Fireplaces and Chimneys: by U.S. Department of Agriculture (U.S. Forest Service). Superintendent of Documents, Washington, D.C. 20402. $0.40.

STOVE DIRECTORY

This is a list of major stove distributors.
Contact them for lists of their local dealers.

SCANDINAVIAN AIRTIGHT STOVES:

Jotul
Kristia Associates
449 Forest Avenue
Portland, ME 04104

Lange
Scandinavian Stoves, Inc.
Box 72
Alstead, NH 03602

Morso
Southport Stoves
Division of Howell Corp.
1180 Stratford Road
Stratford, CT 08497

Trolla
Lyons Supply
Manchester, NH 03100

DOMESTIC AIRTIGHT STOVES:

Better 'N Ben's
C & D Distributors, Inc.
P.O. Box 768
Old Saybrook, CT 06475

Fisher Stoves Inc.
504 South Main St.
Concord, NH 03301

Ram Stoves
Milton Hills
Belfast, ME 04915

Sunshine Stove Works
Norridgewock, ME 04957

Tempwood
Mohawk Industries, Inc.
173 Howland Avenue
Adams, MA 02330

THERMOSTATICALLY CONTROLLED/AIRTIGHT:

Ashley
Martin Industries
1604 17th Ave., S.W.
Box 730
Sheffield, AL 35660

Riteway Mfg. Co.
Marco Industries, Inc.
Harrisonburg, VA 22801

Shenandoah Mfg. Co., Inc.
P.O. Box 839
Harrisonburg, VA 22801

MISCELLANEOUS STOVES & EFFICIENT FIREPLACES:

Arctic, Olympic
Washington Stove Works
P.O. Box 687
Everett, WA 98201

Atlanta Stove Works, Inc.
Atlanta, GA 30307

Atlantic, Monitor
Portland Stove Foundry Inc.
57 Kennebec St.
Portland, ME 04104

Autocrat Corporation
New Athens, IL 62264

Barrel Stove Kit
Country Craftsmen
P.O. Box 3333H
Santa Rosa, CA 95402

Birmingham Stove
and Range Co.
Box 2593
Birmingham, AL 35209

Defiant
Vermont Castings, Inc.
Prince St.
Randolph, VT 05060

Dover
Dover Stove Co.
Main St.
Sangerville, ME 04479

Fatsco
251 N. Fair Ave.
Benton Harbor, MI 49022

Monarch
Monarch Range Co.
Beaverton, WI 53916

Warm Morning
Locke Stove Co.
114 W. 11th St.
Kansas City, MO 64105

Wonderwood
United States Stove Co.
South Pittsburg, TN 37380

AGENCIES

Maryland Energy Policy Office
301 West Preston Street
Baltimore, Maryland 21201
301-383-6810

Maryland Fire Prevention Commission
301 West Preston Street
Baltimore, Maryland 21201
301-383-2520

Maryland State Forest Service
Department of Natural Resources
State Office Building
Annapolis, Maryland 21401
301-269-3776

The National Fire Protection Assoc.
60 Batterymarch Street
Boston, Massachusetts 02110

WATER

At elevations above sea level, water rushing down hillsides or meandering through meadows on its course to lakes, rivers, and oceans has excellent potential as a renewable alternative energy source. Even very small streams have been used to produce power (Saunders 1974).

Water power can be called a renewable source because it is a form of solar energy (Saunders 1974). The hydrologic cycle begins as the sun evaporates the water and then heats the air. Then the hot air rises over the water and carries moisture to the land. When the moisture reaches a certain height where the air is cooler, it turns to precipitation and returns to the earth.

Eventually, the water runs off the land, back to the streams. Then the cycle begins again. The earth's water resources are not only renewable; you could even say they are never really used up, but are continually recycled (Clark 1974).

Physical conditions for using small-scale water power are met in Maryland. Ranging from elevations of 3,360 feet above sea level at Backbone Mountain in Western Maryland to sea level along the shore areas, Maryland's topographic features extend across the State with progressively higher elevations from east to west. This orderly east-to-west sloping contributes to the consistency and force of stream flows.

Average precipitation is 42 inches per year (Walker 1970), an adequate amount to sustain most stream flows during much of the year. Usually, the wettest seasons are spring and summer; the driest are fall and winter.

To protect this renewable energy source, we must be careful to preserve the balance of the hydrologic cycle and its seemingly countless interdependent processes. For example, pollution is not only dangerous because it dirties the air we breathe or the water we drink, it may also throw the hydrologic cycle out of kilter.

One example of how urban pollution can affect the hydrologic cycle (and, in turn, a hydro power site) is as follows: (1) heat islands are created around urban centers because of asphalt, people, and machines; (2) increased air temperatures around cities can cause increased rainfall in localized areas where cold fronts clash with heat islands; (3) increased, localized rainfall can lead to flooding; (4) flooding, in turn can lead to increased erosion and eventually to sedimentation of streams and rivers; and (5) as sediments build up, stream flows can be altered, and the original advantages of a hydro power site are destroyed.

The above, very simplified example is included to show you that although water power is an excellent alternative energy source, it will be renewable only so long as we treat the many components of its existence with respect and proper management.

1. In which areas of Maryland is small-scale water power a potential energy alternative?

   According to the U.S. and Maryland Geological Surveys, Maryland is divided into five physiographic, hydrologic provinces: the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau (Walker 1971).

   a. The Coastal Plain includes the Eastern Shore and most of the western shore of the Chesapeake Bay. Flows of streams in these areas are affected by the tides of the Bay and the Atlantic Ocean.

      On the Eastern Shore, the land is low and flat, and poorly drained. The streams are small and very sluggish. The land of the opposite shore is more rolling, but the streams are only slightly less sluggish than those of the Eastern Shore (Walker 1971).

      This province is not promising for small-scale water power.

   b. The Piedmont (Central Maryland) landscape is rolling with low hills and ridges; the land is well drained. There are many streams and rivers flowing toward the Chesapeake Bay. The stream slopes are fairly steep.

      Residents of this province can use small-scale water power.

   c. The Blue Ridge province (use the Catoctin and South Mountains as points of reference) is characterized by rugged terrain. Catoctin Creek and its tributaries provide excellent opportunities for hydro power sites.

   d. The Valley and Ridge (Great Valley and Allegheny Ridges) province is actually two sub-provinces.

      The Great Valley's topography is that of gently rolling hills and broad lowlands. The land is well drained by Antietam and Conococheague Creeks. Streams in the province are gently sloped and follow meandering courses. Although the streams are not as fast flowing as those in the Piedmont, Blue Ridge, or Appalachian Plateau provinces, they are very dependable and maintain uniform flows throughout the year.

      The Allegheny Ridges region is hilly and is well drained by fairly steep, swift streams.

      These provinces are well suited for small-scale water power.

   e. The Appalachian Plateau province is a broad upland with very pronounced relief and rugged topography. Its streams follow very steep gradients creating many rapids and falls systems as they roll to the Ohio River.

      Water power plants would be effective in this province on the secondary streams. Some of the larger streams may be too strong to harness on a small scale.

   (The provinces are listed here as they cross the State from east to west.)

2. What does "small-scale" mean as applied to water power?

   The term "small-scale" is used here to mean the size of a water plant needed to run an individual's machinery and/or to supply his home with electrical power.

   It would also apply to small groups whose members wish to pool their resources to build a more elaborate, more expensive water power plant.

3. If four out of the five provinces in Maryland are well suited for the use of hydro power, why are there so few water power plants?

   a. The major reason is that fossil

fuels were abundant at one time. People switched from using renewable sources such as wood and water power to the easier "press-a-button, pull-a-string" methods.

As you drive around Maryland, you can still see several abandoned water power sites. In Baltimore's Druid Hill Park there is a rather large, old water wheel still standing. The wheel was part of a system used to power the old Woodbury Mills.

b. There are many statutes, contracts, ordinances, "understandings," etc. concerning water rights, environmental considerations, and so on.

For the benefit of the whole, supposedly, federal and State financial aid policies were originally written to encourage development. For this reason, they seem to favor the big power companies rather than the farmer or homeowner (Clark 1974).

These obstacles are referred to as institutional barriers.

Governmental agencies are aware that many policies need revision. For example, the U.S. Energy Research and Development Administration is supporting The Johns Hopkins University Applied Physics Laboratory (APL) to study the institutional barriers affecting the "redevelopment of small,* low-head hydroelectric generating facilities in New England" (APL 1977).

*According to our definition of small (2.), these facilities are medium sized.

4. What is water power used for?

   a. To produce mechanical energy (to run machines)

   b. To produce electrical energy

   c. To pump water (thus replacing electrically powered pumps)

5. What should I do first to find out if my stream is suitable for a small-scale water power plant?

   There are many factors, both technical and institutional, that must be considered before attempting to install a water power plant. Among these are rate of water flow, the "head," water rights, environmental effects, applications, and permits.

   The first step is to read up on the subject and/or to contact your local soil conservationist, extension service agent, or Resources Conservation District representative (a U.S. Department of Agriculture agent). These sources are usually very helpful.

6. What types of devices are used to harness water power?

   a. Water wheels are used to power mechanical systems for cutting, grinding, etc. There are four major types: overshot wheel, breast wheel, undershot wheel, and Poncelet wheel (Saunders 1974).

   b. Water turbines are used to produce electrical power. There are three major types: cross-flow turbine (Michell or Banki), impulse or Pelton wheels, reaction turbine (Francis wheel, Kaplan turbine, Hoppe turbine, and others) (Saunders 1974).

   c. Hydraulic rams are used for pumping water.

7. What does the term "head" mean?

   "Head" is but one term of many included in the hydrologist's glossary. The term refers to the vertical distance (in feet) the water falls in a given distance. This measurement is very important. The rate of flow is multiplied by the head

to determine how much power a water power plant can provide at a given site (Saunders 1974).

8. Will I have to build a dam?

In most cases, it is necessary to build a dam. Not only does a dam usually increase the reliability and power of a stream's flow, it also gives you a means to regulate the flow and store the water (if desired).

Remember, you must consult with the local and often the State authorities to determine if your hydro plant will affect other plants, the environment, and/or residents downstream. Each local water district has its own criterion and statutes to ensure that all citizens have an adequate water supply (Scher 1974).

References Cited

APL (The Johns Hopkins University Applied Physics Laboratory). 1977 (July-September). "Information Acquisitions for Low-Head Hydroelectric Power Facilities in Maine, New Hampshire, and Vermont." Quarterly Report - Energy Programs (APL/JHU EQR/77-3).

Clark, Peter. 1974. The New & Revised Natural Energy Workbook. Berkeley: Visual Purple.

Saunders, Robin. 1974. "Harnessing the Power of Water." In Energy Primer, pp. 52-72. Menlo Park: Portola Institute.

Scher, Les. 1974. "Building and Health Codes." In The Mother Earth News, (No. 28) July 1974, pp. 62-66.

Walker, Patrick N. 1970. Water in Maryland: A Review of the Free State's Liquid Assets. U.S. Geological Survey and Maryland Geological Survey.

Walker, Patrick N. 1971. Flow Characteristics of Maryland Streams. U.S. Geological Survey and Maryland Geological Survey. (Report of Investigations No. 16).

RECOMMENDED READING

"Harnessing the Small Stream": by Popular Science (1947). In Cloudburst, (1973), Cloudburst Press, Box 79, Brackendale, British Columbia, Canada. $3.95. (Though an old publication, it is an excellent resource.)

Windmills and Watermills: by John Reynolds (1971). Praeger Publishers, 111 Fourth Avenue, New York, New York 10003. $8.95.

Water Measurement: by U.S. Bureau of Reclamation (1967). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. $2.50.

Low-Cost Development of Small Water Power Sites: by Volunteers in Technical Assistance (1967). VITA, 3706 Rhode Island Avenue, Mt. Ranier, Maryland 20822. $1.00

MANUFACTURERS

The list of manufacturers is too lengthy to include here. You can find the list on p. 72 in Energy Primer (see General References).

agencies

Volunteers in Technical Assistance
3706 Rhode Island Avenue
Mt. Ranier, Maryland 20822
(excellent contact for information and guidance)

Maryland State Department of Natural Resources
Tawes State Office Building
Annapolis, Maryland 21401
(State policy regarding natural resources)

Maryland Geological Survey
214 Latrobe Hall
The Johns Hopkins University
Baltimore, Maryland 21218
(Water resource reports, State and county maps, geology)

Maryland State Department of Health,
Bureau of Resources Protection
2305 North Charles Street
Baltimore, Maryland 21218
(Water supplies; public and private)

U.S. Department of Agriculture
Soil Conservation Service
Room 522 Hartwick Building
4321 Hartwick Road
College Park, Maryland 20740
(erosion control, farm ponds)

Maryland Energy Policy Office
301 West Preston Street
Baltimore, Maryland 21201
(may save you some telephone calls)

Maryland State Department of Water Resources
Tawes State Office Building
Annapolis, Maryland 21401
(Permits, hearings, licenses)

University of Maryland
College of Agriculture
College Park, Maryland 20740
(Soil conservation districts, drainage of agricultural land)

U.S. Geological Survey
Water Resources Division
8809 Satyr Hill Road
Parkville, Maryland 21234
(Stream flow, water resources reports, maps)

U.S. Department of Commerce
Environmental Science Services
Room 34 Symons Hall
University of Maryland
College Park, Maryland 20740
(weather reports and statistics)

BIO-GAS / METHANE

For millions of years, bacteria have been breaking down, decomposing, and decaying organic material on earth. If the bacteria were not performing this function, the earth's surface would be littered with dinosaur bones and the remains of trees, ages old.

The bacteria that decompose organic matter can be generally classified into those that do so in the presence of oxygen (aerobic bacteria) and those that function in the absence of oxygen (anaerobic bacteria).

Some of the anaerobic varieties of bacteria create "bio-gas" (methane) as a by-product of their organic decomposition. Bio-gas is flammable and can be used for such utilitarian purposes as cooking. The gas is being produced in nature constantly. For example, in the natural environment of the bog, it has often been called "marsh" or "swamp gas" and in rare occasions is ignited ("marsh lights"). Thus, the use of bio-gas as an energy alternative is a matter of containing and maximizing the natural anaerobic decomposition of organic matter.

As long as organic matter is produced, bio-gas can be produced. Bio-gas is a renewable energy resource in the best definition of the term.

1. What kind of organic wastes can be used in Maryland to produce bio-gas?

   a. Cattle, hog, chicken, and other livestock manures

   b. Sewage

   c. Kitchen vegetable scraps

   d. Newspapers

   e. Food processing residues

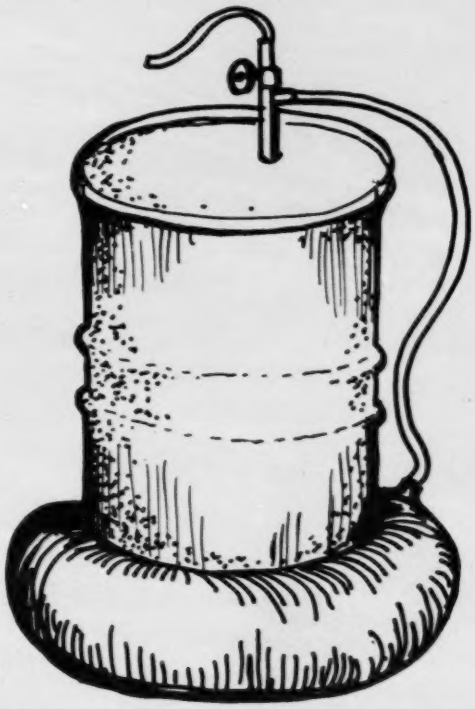
2. What is a bio-gas or methane gas digester?

   An airtight container which holds organic material undergoing anaerobic decomposition is called a digester.

   An outlet, of course, is needed to let the bio-gas escape, usually to a gas storage system. A means is often provided to stir the slurry of organic material inside the digester, because organic debris can float to the top of the slurry and slow down the digestion process.

   A means is often provided as well to maintain an approximate temperature of 90 degrees Fahrenheit within the organic slurry, because that temperature is optimal for the anaerobic bacteria to function producing the bio-gas.

   In some digester prototypes, a percentage of the bio-gas (methane) is burned to heat the digester. A few



55 GAL. DIGESTER - BIO-GAS IS STORED IN TIRE INNER TUBE

experimenters have placed digesters in modified greenhouse structures to heat the digester and others have used solar systems to warm the organic slurry.

3. What is the composition of bio-gas?

   Bio-gas is about 65-percent methane and 33-percent carbon dioxide with small amounts of nitrogen, hydrogen, carbon monoxide, hydrogen sulfide, and water.

   Pure methane is combustible with an energy value of 1,000 Btu per cubic foot of gas. But, since bio-gas is only 65-percent methane with about 33-percent non-combustible carbon dioxide, the energy value is actually lower at about 600 Btu per cubic foot of gas.

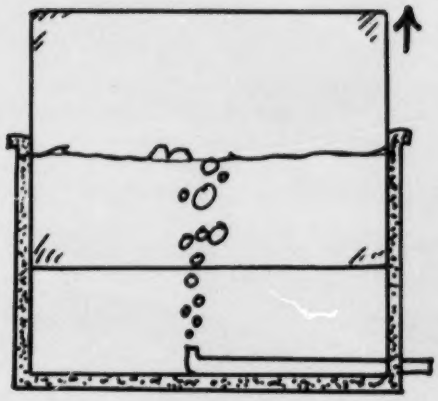
   Since the energy value of bio-gas is about one-third less than that of pure methane (600 Btu/cubic foot vs. 1,000 Btu/cubic foot), it takes about one-third more bio-gas to give the same heat value as pure methane (natural gas). Any appliance that runs on natural gas (which is primarily methane) will run on bio-gas under pressure (0.3 pounds per square inch). These appliances could include gas stoves, gas refrigerators, lamps, hot-water heaters, etc.

4. How much bio-gas can I expect to get from what amount of liquid slurry?

   This depends on the organic material used for the digester slurry. The range of bio-gas can be 0.5 to 1 cubic foot per 1 pound of liquid slurry. In terms of digester capacity, about 25 to 30 cubic feet of bio-gas are produced per cubic foot of digester capacity.

5. How is bio-gas stored?

   In small digester systems, bio-gas has been stored in tire inner tubes. In larger systems, bio-gas is stored in tanks. The tanks are specially



constructed so that an inverted tank sits in such a way that it can float and slide inside the outer, bottom tank.

The bio-gas piped into this water filled storage complex rises and collects under the inside of the inverted tank. The inverted tank rises as it fills with bio-gas.

Bio-gas can also be compressed into high pressure tanks using a gas compressor. However, it has been pointed out that it takes about as much energy to compress the bio-gas into the tanks as there is energy content in the gas. So, little is gained considering the net energy factor.

6. How much does a digester cost?

   A 55-gallon drum digester using an inner tube for gas storage can be built for under ten dollars. A 300-gallon digester was built for 150 dollars out of surplus tanks, hoses, and valves.

   Ram Bux Singh, a pioneer in bio-gas digester operation and design, says that a digester capable of producing 100 cubic feet of gas per day could be built for 400 dollars. In short, it depends on the materials you can "scrounge" (such as tanks) and which you must purchase.

7. Would a digester be practical in Maryland?

   If you do not own a horse, cow, pig, etc. or you do not have access to the manure generated by large animals, it is doubtful that a digester would be practical for you. Animal manure provides the best organic material for anaerobic digestion, and you need (at least) the amount of manure provided by a large animal to generate any appreciable volume of gas.

   If you have access to a small amount of livestock manure, then a digester may be practical to generate gas to cook with. However, you would not have enough gas production to heat your house, for example. To produce enough bio-gas to heat your home, run large gas engines, and meet total lighting, refrigeration needs, etc., you would need to own a large cattle ranch or feedlot operation.

   A 55-gallon drum digester was built by a member of the Heathcote School of Living (in Maryland). The digester was partially (50 percent) filled with a manure slurry. The digester generated enough bio-gas during three consecutive months to cook one meal per day on a small gas burner (a practical demonstration but perhaps not on the scale to which we are accustomed).

   It is generally agreed that the larger the manure supply and digester, the more practical and feasible bio-gas becomes as an alternative energy source. In Maryland, the cold temperate climate can make it difficult to keep a digester operational during the winter. However, bio-gas is currently being generated and used to operate machinery successfully at the Patapsco River sewage treatment plant.

8. Are there any other useful by-products of the anaerobic digestion of organic wastes?

   Yes. During anaerobic decomposition in the digester, nitrogen remains in the slurry solution. Whereas during aerobic decomposition (as occurs in a compost pile), nitrogen is eliminated as a gas. Thus, the spent organic mixture is a nitrogen-rich fertilizer that can be directly applied to your garden. In fact, a number of individuals argue that the monetary value of spent organic slurry as a fertilizer may exceed the monetary value of the bio-gas.

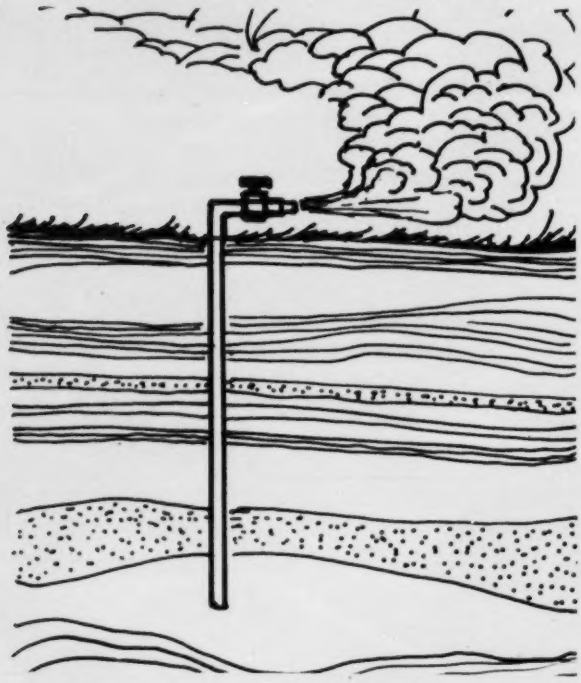
RECOMMENDED READING

Other Homes and Garbage: Designs for Self-Sufficient Living: by Jim Leckie, Gil Masters, Harry Whitehouse, Lily Young (1975). Sierra Club Books, 530 Bush Street, San Francisco, California 94108. $9.95 - Perhaps one of the most comprehensive books covering topics such as home design, water power, insulation, solar energy, water supply, agriculture, aquaculture, and methane (bio-gas) production. The chapter on bio-gas/methane discusses gas production from a theoretical perspective. All the formulas and technical information (on specific gas production per organic material used) are provided. This chapter is well written and thoroughly researched. However, there are no specific step-by-step plans provided for the construction of a methane digester in this chapter.

Practical Building of Methane Power Plants for Rural Energy Independence: by L. John Fry. Undercurrents Books, 11 Shadwell, Uley, Dursley; Gloucestershire, England. $12.00 - Plans for three types of digesters are outlined. Plenty of personal experience with digesters described in the book's 96 pages.

Anaerobic Digestion of Dairy Cow Manure at the State Reformatory Honor Farm: by Ecotope Group (1975). Ecotope Group, 747-16th Avenue East, Seattle, Washington 98112. $8.00 - Successful large methane digestion system is described.

GEOTHERMAL



Geothermal energy is the heat from inside the earth (Gabel 1975). As naturally radioactive materials (such as uranium and thorium) decay, they generate enough heat to produce molten hot rock in the earth's crust (Sheahan 1976).

Steam is created as ground water comes in contact with the molten rock. If the expanding steam can find its way to the earth's surface, geysers, fumaroles, and pools of boiling mud (such as those found in Yellowstone Park) may be formed.

Geothermal regions are usually, not always, associated with known volcanic activity and/or earthquake zones. In the earthquake zones, crustal weaknesses enable deep-seated heat to rise nearer to the surface of the earth.

Geothermal power plants may be built in some areas where the steam is trapped to tap the naturally occurring steam to produce electricity (Sheahan 1976).

The above information is very general indeed. It is presented here to give you the basic ideas behind considering geothermal energy as an alternative source of energy.

Following are a few questions and answers that may further enhance your understanding.

1. How can geothermal energy be used?

   a. Major interest has been concentrated on power generation. Tapped steam is channeled to the earth's surface through pipes and on through a turbine-generator (Sheahan 1976).

      For example, in Laradello, Italy, a geothermal plant was built in 1904. Though the power generated at first was in very small amounts, today the plant provides enough power to run much of the nation's railroads (Gabel 1975).

      "The Geysers" plant, built by the Pacific Gas and Electric Company in Sonoma County, California started producing power in 1960. The plant is designed to eventually produce over 1,000 megawatts of power.

      Other geothermal sites where power plants are in operation are: Japan (eight plants), New Zealand (two plants), the USSR (two plants), Mexico (one plant), and Iceland (one plant).

   b. Space heating from geothermal sources has been developed in the city of Reykjavik, Iceland and in Boise, Idaho. Other homes, hotels, apartments, and other buildings are heated by geothermal heat in Hungary, Japan, New Zealand, the USSR, and a number of other countries.

   c. Other uses are to provide heat for industrial processes, in fish farming, for swimming pools, for greenhouses, and many other heat-utilizing activities.

2. Is geothermal potential being explored in Maryland?

   Yes. Ocean City/Delmarva Peninsula is an area of potential geothermal resources in the Atlantic Coastal Plain region. It is one area of eight being studied by the Johns Hopkins University Applied Physics Laboratory (APL) in cooperation with the U.S. Energy Research and Development Administration, Department of Geothermal Energy (ERDA/DGE).

   The APL prepared a scenario for the development and use of these resources. There are three phases to the program. They are: resource exploration and assessment; utilization demonstration; and resource development.

   "The first phase is now in progress by ERDA/DGE contractors and is expected to reach the stage that will allow one or more utilization demonstration projects to begin by 1981" (APL 1977).

3. Are there any disadvantages or dangers associated with geothermal energy?

   a. One major disadvantage is that geothermal resources must be exploited at the sites where they are found. Although electricity can be transported through power lines, it is not practical to do so over long distances.

   b. Geothermal steam is not as hot as steam produced by conventionally fueled power plants. Therefore, the turbines must be larger to produce the same amount of power as the other plants (Sheahan 1976).

   c. There is some concern that disturbing the trapped steam in earthquake regions may cause increased quake activity.

      Along this same line, some experts are leery of upsetting the heat regimen of the earth's core. Dr. Robert Rex of the University of California at Riverside has speculated that geothermal mining will more likely "diminish earthquake hazards rather than enhance them" (Gabel 1975).

References Cited

APL (Johns Hopkins University Applied Physics Laboratory). 1977 (July/September). "A Scenario for Geothermal Energy Use in the Atlantic Coastal Plain." Quarterly Report - Energy Programs. APL/JHU, EQR/77-3. Laurel, Maryland: The Johns Hopkins University Applied Physics Laboratory.

Gabel, Medard. 1975. Energy, Earth and Everyone. San Francisco: Straight Arrow Books.

Sheahan, Richard T. 1976. Fueling the Future: An Environment and Energy Primer. New York: St. Martin's Press.

RECOMMENDED READING*

State Policies for Geothermal Development: by Douglas M. Sacarto (1976). Renewable Energy Resources Project, National Conference of State Legislatures, 1405 Curtis Street, Suite 2300, Denver, Colorado 80202.

Assessment of Geothermal Resources of the U.S.: edited by D. E. White and D. L. Williams (1975). U.S. Geological Survey's Branch of Distribution, 1200 South Eads Street, Arlington, Virginia 22202. Free.

If you are really interested in following the progress of geothermal research, you may wish to subscribe to: The Geyser, international geothermal bi-weekly newsletter. Box 1525, Beverly Hills, California 90213. $85.00/year.

*These readings are of a technical nature. More general overviews written in lay terms can be found in Gabel and Sheahan listed in the References Cited section.

REFERENCES

Energy for Survival: by Wilson Clark (1974). Anchor-Doubleday, 501 Franklin Avenue, Garden City, New York 11530. $4.50.

An historical analysis of the changing cultural demands for various types of energy. In short, the book tells you how the energy crisis developed, why we do have a crisis, and what energy alternatives are open to us. A very well-documented book which stresses strongly and logically that we have very little time left. If a friend says, "I don't believe we have an energy crisis," send him a copy of this book.

Energy Primer: by Portola Institute (1974), 558 Santa Cruz Avenue, Menlo Park, California 94025. $5.50.

In the format of the Whole Earth Catalog, there are reviews of products and books plus descriptive articles on wind, solar, water, biofuels (wood, methane, alcohol), integrated systems and more. Although the book is called a "primer," it is very comprehensive. There are plenty of diagrams, charts, and photos. It is a source book much like a renewable energy "yellow pages," presenting ideas and products for the energy-conscious shopper.

Other Homes and Garbage: Designs for Self-Sufficient Living: by Jim Leckie, Gil Masters, Harry Whitehouse, Lily Young (1975). Sierra Club Books, 530 Bush Street, San Francisco, California 94108. $9.95.

A very well-written and well-researched text (regardless of the title). Most of the renewable energy resources that could be implemented on a backyard level are discussed: solar, wind, hydro, methane digesters, and chapters on agriculture and aquaculture. Some of the strongest chapters from an informational standpoint are on insulation, calculating heat loss, water power, and bio-gas (methane) production. Technically, this is a more comprehensive book than the Energy Primer, but that is because it is more academically oriented. A highly recommended book on renewable energy sources with great illustrations, it belongs in everyone's reference library.

Kilowatt Counter: by Gil Friend and David Morris (1975). Alternative Sources of Energy, Route 2, Box 90-A, Milaca, Minnesota 56353. $2.00.

A general explanation for the layman as to what energy is, how it is measured, and its various forms (kinetic and potential). If you are not sure what a Btu is (although you have heard the term used often), or you do not quite understand what a kilowatt is, this booklet would be helpful to you. Some of the topics are: heat units, mechanical units, electrical units, power, converting between units, net energy, and energy as applied to solar, wind, and biomass energy sources. Kilowatt Counter is an easy way to learn about energy without having to take a physics course (another book worth having as a reference.

Alternative Sources of Energy: bimonthly magazine. Route 2, Box 90-A, Milaca, Minnesota 56353. $10.00 per year.

This periodical covers topics on solar, wood, methane, and other renewable energy sources as well as food sources. Many backyard and neighborhood energy/food projects are discussed. It is an exceptional magazine by the people (and for the people) actually experimenting with

renewable energy alternatives. Energy workshop and conference announcements, book reviews, interviews, and regular columns (e.g., on wind energy) are featured. If you are serious about renewable energy alternatives, you could not subscribe to a better magazine.

Energy Book #1: by John Prenis (ed.) (1975). Running Press, 38 South 19th Street, Philadelphia, Pennsylvania 19103. $4.00 ($.025 postage).

Solar water heaters, homemade wind generators, backyard bio-gas plants are some of the topics in this book. Technical, semi-technical, and funky articles are informative and enjoyable to read. To quote the editor, John Prenis, "This book is respectfully dedicated to all the backyard experimenters and basement tinkerers who have shown that alternative energy research need not be the exclusive domain of 'experts'."

Energy Book #2: by John Prenis (ed.) (1977). Running Press, 38 South 19th Street, Philadelphia, Pennsylvania 19103. $5.00.

An extension of Energy Book #1 with a sampling of the alternative and renewable energy field. More technical in nature than Energy Book #1, however. Some of the articles are: methane bus, operating experience with an experimental heat pump system, solar house design, a recording anemometer, working towards a wind powered homestead, and more, of course.

People and Energy: a monthly periodical 1757 "S" Street, N.W., Washington, D.C. 20009. $10.00 per year.

This is an excellent periodical briefly covering events, projects, conferences, and people on a nation-wide basis as related to nuclear energy, solar energy, and various appropriate technologies. Usually, one in-depth article is included in each newsletter on an up-to-date subject.

Rainbook: Resources for Appropriate Technology: by Rain (1977), 2270 Northwest Irving, Portland, Oregon 97210. $7.95.

Details on compost toilets, woodstoves, solar greenhouses, solar collectors, wind energy systems, etc.

In the Bank or up the Chimney: by U.S. Housing and Urban Development Administration (1976). Chilton Book Company, Radnor, Pennsylvania 19089. $1.95.

This is a very fine booklet on ways to conserve and winterize your house. You are shown how to calculate heat loss and how to conduct your own energy audit of your home. Tips and suggestions on insulation, storm windows, etc.

Producing Your Own Power: by Carol Hupping Stoner (ed.) (1974). Rodale Press, Inc., Book Division, Emmaus, Pennsylvania. $8.95.

A very straightforward, easily read handbook on the use of renewable energy alternatives. Highly recommended.

National Center for Appropriate Technology, Box 3838, Butte, Montana 59701.

A federally funded organization offering grants for projects such as solar greenhouses, workshops on alternative energy, and solar demonstration projects. The Center now has a newsletter describing what projects are being funded. All projects funded through the Center must be designed and oriented for low-income families and individuals.